ArcGIS Data Models

ArcGIS Parcel Data Model

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This document provides an introduction to the ArcGIS Parcel Data Model. At this point it is a conceptual model that is being used to support the development of sample databases and further refinement of the model. It is also being used in the development of post-8.1 ArcGIS capabilities for parcel users.

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Preface

This document describes a conceptual data model for parcel land records information in the ArcGIS technology. It is a starting point for the development of parcel level management and supporting functionality in the ArcGIS environment.

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We would like comments on this version by April 20, 2001.

1. Introduction

A *land parcel* has many meanings in different organizations, disciplines, and situations. From a parcel mapping perspective, local governments frequently use property tax parcels as the basis for parcel management. Other organizations begin parcel mapping with an ownership parcel defined by the official Register of Deeds. Still others use zoning, land use, mineral rights or farmland conservation as the basis for parcel mapping. Depending on the business perspective, parcels are many things to many people.

The ArcGIS Parcel Model accommodates the varied applications and parcel definitions using an open and flexible object-based data model. The geographic building blocks for parcels are points (corners), lines (boundaries), polygons (parcels), and related tables of attributes (i.e., owner and tax bill information). The object approach supports a continuous range of implementation scenarios from the most basic to complex. For example, an organization can begin directly with tax parcel polygons and link them to a tax roll. Record measurements of parcel boundaries can be added incrementally over time to build a complete record of measurements for the parcel polygons without starting over or losing any of the effort that went into building the polygons.

The ArcGIS Parcel Model captures the collective experience gained from 20 years of managing parcels using GIS technology. While the model is general and flexible, the unique needs of a variety of parcel management users have been addressed in the design process. For example, the parcel maintenance staff can track multiple bearings and distances for boundary lines; the real property manager can attach value and use attributes to tax parcel polygons; and the land planner can analyze historical land ownership patterns.

The purpose of the ArcGIS Parcel Model is to describe parcel information to support local government and private sector decision-making.

2. Parcel Mapping Methods

Parcel mapping is the heart of most local government geographic information systems. There are nearly as many parcel mapping methods and standards as there are parcel mapping jurisdictions. The adage "standards are great, everyone should have one" often prevails for parcel mapping. Many parcel mapping standard variations deal with parcel map presentation. Including things like annotation style and placement, line widths and types, and map sheet style and size. Others deal with construction method, accuracy, source documents, and certification of who can maintain the maps.

Although there are many approaches to parcel mapping and a plethora of requirements, there are three basic methods used to produce parcel maps: cartographic constructions, computations, and adjustments. The parcels resulting from these three parcel mapping methods have different characteristics.

2.1 Cartographic Constructions

Cartographic constructions are map-based editing tasks like closing polygons, extending lines, snapping to existing geometry, and following or copying a line from another map. Boundaries from cartographic tools might be sketched in a manner that provides a spatial inventory of the parcels, placing them in correct relation to each other, but not focusing on having each boundary reflect its recorded length or direction. In this case a boundary can be considered "placed" since it may reflect the correct relative location of boundaries but not the exact absolute positioning of the boundary.

2.2 Computations

Computations have a set of rules and are repeatable from operator to operator. The most commonly used parcel computation tool is coordinate geometry. Boundaries constructed from computations are rule based. In these cases, the rules of construction need to be carried with the boundary in order to repeat the computation. Typically computed boundaries are generated from the results of surveys expressed on deeds and plats. As examples, computing a parcel boundary from distances and directions and calls in a deed, computing the smaller subdivisions (under one sixteenth) of Public Land Survey System (PLSS) sections from a set of subdivision rules, finding new points from distance-distance intersections or boundaries defined as a distance from an existing line, such as 300 feet east of a west boundary.

2.3 Adjustments

Adjustments are based on known and established algorithms that are repeatable from one operator to another. Adjustments work with the measurements and are mathematically based. Land surveyors often use adjustments like least squares analysis for field observed measurements. Adjusting traverses by closing, typically to establish whether a traverse meets statutory requirements, like one part in 3,000 or using the compass rule are another examples of parcel adjustments.

Adjusted boundaries are based on measurements. Measured or measurement based boundaries are typically collected by survey measurement. In these cases the quality of the measurements defining the parcels are known, a statistical estimate of positional quality can be determined, and adjustments can be re-run when better information is added.

2.4 Annotation

All three parcel mapping methods have annotation requirements. The annotation for boundaries is often the legal boundary distance and source information for the distance. This means that the annotated distance is not the distance computed from the GIS, it is the distance as officially recorded. The reasons for the differences can be related to the parcel mapping methods and differences in coordinate distances in various coordinate systems. Most jurisdictions do not annotate boundaries with directions. This is because the basis of bearing for directions can vary from parcel to parcel. Some jurisdictions annotate the angles between lines. Parcel annotation may also include: the parcel tax number, lot number, subdivision name and the owner's name for the parcel. Annotation is an important part of the parcel map. The style, placement and content of the annotation are often the key features of a parcel map.

2.5 Applying the Parcel Mapping Methods

Most jurisdictions use a combination of parcel mapping methods to produce and maintain parcel maps. For example, initially boundaries might be computed using coordinate geometry applied to deed descriptions and plats. The results of this computation might be cartographically fit into the existing parcel information. Placing a line to close a parcel or capturing a parcel boundary by heads up digitizing from a digital orthophoto might enhance uncertain boundary descriptions. The underlying framework for the parcel map might be generated by global positioning system (GPS) and ground based survey measurements. For example PLSS section corners, subdivision exteriors and road centerlines might be accurately surveyed and positioned as a reference for successive mapping.

The ArcGIS Parcel Model accommodates all three methods of construction. A jurisdiction can settle on one method or use a combination of methods. It will also be possible to migrate from one method to another. For example a jurisdiction could start with a parcel map constructed by placing lines cartographically and then migrate to a computational or measurement approach. The annotation from the cartographic placement can be preserved or persisted as the methods of construction migrate.

3. Parcels

There are three features that define parcels in the ArcGIS Parcel Model. These are the *ownership, encumbrances,* and *separated rights.* These are the core of the parcel model because these three features are the basic parcel building blocks. These three features are each represented as polygons in the ArcGIS model.

3.1 Ownership Parcels

The ArcGIS Parcel Model begins with an ownership parcel. The simplest and broadest definition of a an ownership parcel is:

> *A parcel is a unit of real property with rights and interests (Moyer and Fisher, 1973)*

The Federal Geographic Data Committee (FGDC) expanded this definition slightly:

> *A parcel is a single cadastral unit, which is the spatial extent of the past, present, and future rights and interests in real property (FGDC, 1999)*

The ownership represents the surface ownership parcel polygons. The surface ownership is the most commonly used and recognized fee simple ownership. The mineral estate is described in the separated estate and easements across the land are represented in encumbrances. The ownership parcels are non-overlapping polygons. This means they are a continuous non-overlapping coverage of the area being mapped.

The *ownership* feature is an interpretation of the legal descriptions into parcel polygons.

> *In a simplified context ownership of property is conventionally considered to consist of two elements: possession and title. Ownership of property is typically considered to exist when an individual holds one of the elements and is has a right to the other.*
>
> *Brown, 1969, p.110*

The O*wnership* feature is characterized as:

- Continuous – All land is accounted for to the jurisdiction boundary of the person, organization or government body modeling parcels. Continuous means that the entire jurisdiction or area being mapped is accounted for and mapped with ownership parcel polygons. The ownership of each piece of land is determined. Some of the ownership might be a right of way, or the exact name of the owner may not be known, but there are no areas without a surface ownership.

- Non overlapping – All land has a single set of current owners. If the surface ownership appears to overlap it may be an error in a legal description or it could be an area of ownership conflict or uncertainty. There may also be a time component of ownership. For example in the case of a prescriptive right of way, a landowner has relinquished their legal rights in the land falling within the right of way for a period of time. At some time in the future the land in the right of way may revert back to the original landowner. These areas may have an attribute indicating whom the reversion owner is to indicate that the area would revert to another parcel, typically an adjoining parcel, lands if the right of way is vacated.

- Conflict Identified - If there is a conflict in adjoining lands, it is either resolved by determining to which landowner the conflicting land is assigned or by indicating in the attributes that the polygon area is a gap or overlap of uncertain ownership.

Non-Overlapping

How can ownership parcels be non-overlapping when it is apparent that legal descriptions often create apparent overlaps or leave gaps? Figure 1 illustrates three (3) interpreted parcels.

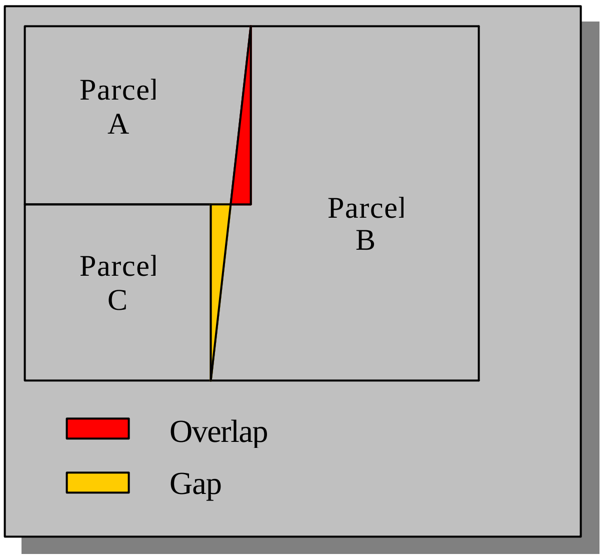


Figure 1 – Ownership Parcel Gaps and Overlaps

These three interpreted parcels have an overlap between Parcels A and B and a gap between parcels B and C. The overlaps and gaps may be real or they may be apparent from the records and construction information. In the interpreted parcels there are five polygons, parcel A, parcel B, parcel C, the overlap polygon and the gap polygon.

Condominiums

Many jurisdictions have condominiums or other structures that form three-dimensional surfaces with different owners on different levels of the structures. These buildings or structures are part of the surface estate with a vertical aspect and are called *vertical parcels* in this discussion. In some jurisdictions condominiums may look the same as subdivision plats with the units laid out as if they were lots and the common elements looking like rights of way and out lots. Other condominiums are stacked or vertical parcels that come into play when the condominium is a building or structure.

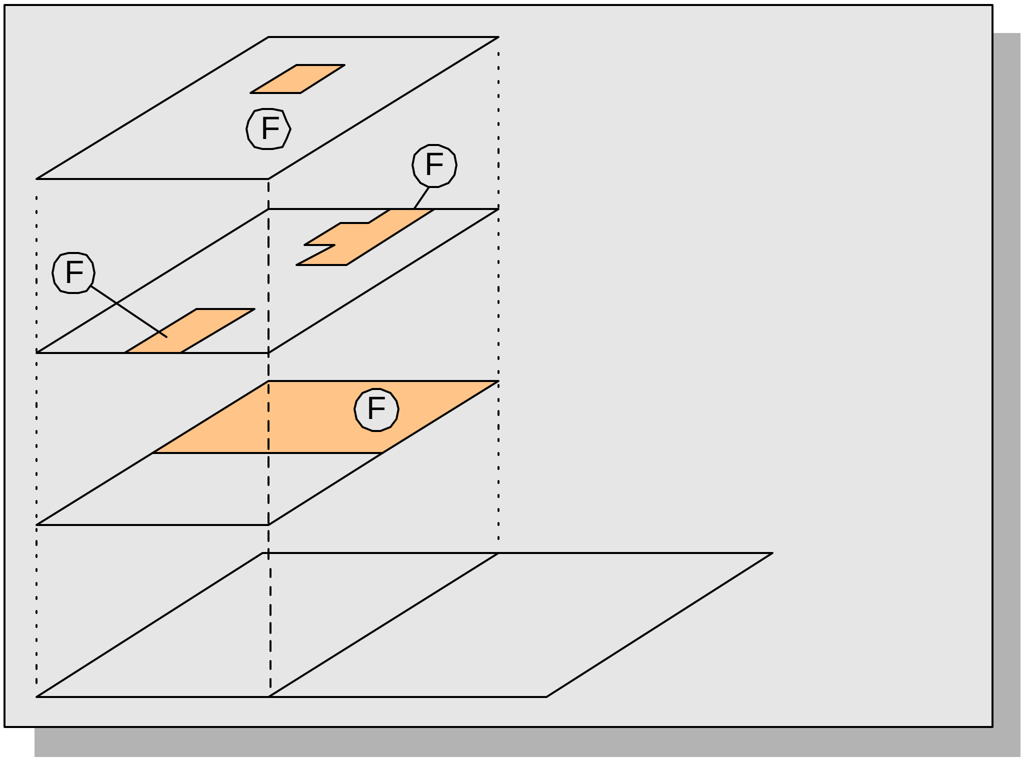


Figure 2 – Vertical Parcels

Figure 2 illustrates a vertical parcel that is a condominium building with condominium unit F that is on three separate floors. Unit F is connected by common elements, such as stairways and elevators. The common elements appear as "holes" or gaps through the elements of Parcel F. The common elements provide access to the parcels in the vertical condominium similar to the way a right of way provides access to more traditional "flat" parcels.

In the ArcGIS Parcel Model there are several ways to model or represent vertical parcels;

- a single outline polygon pointing to multiple parcel records,
- a single outline polygon pointing to another series of polygons that represent the levels or floor, or
- a single outline polygon that points to a three dimensional model of the building.

A single outline polygon pointing to a series of parcel records has one graphic of the condominium. In this approach the information about multiple owners is stored in attribute tables, but there is not an accompanying graphic that outlines the footprints or polygons of the separate owners in the condominium. Figure 3 illustrates this approach. In this first approach an image of the condominium plat could also be attached to the outline polygon.

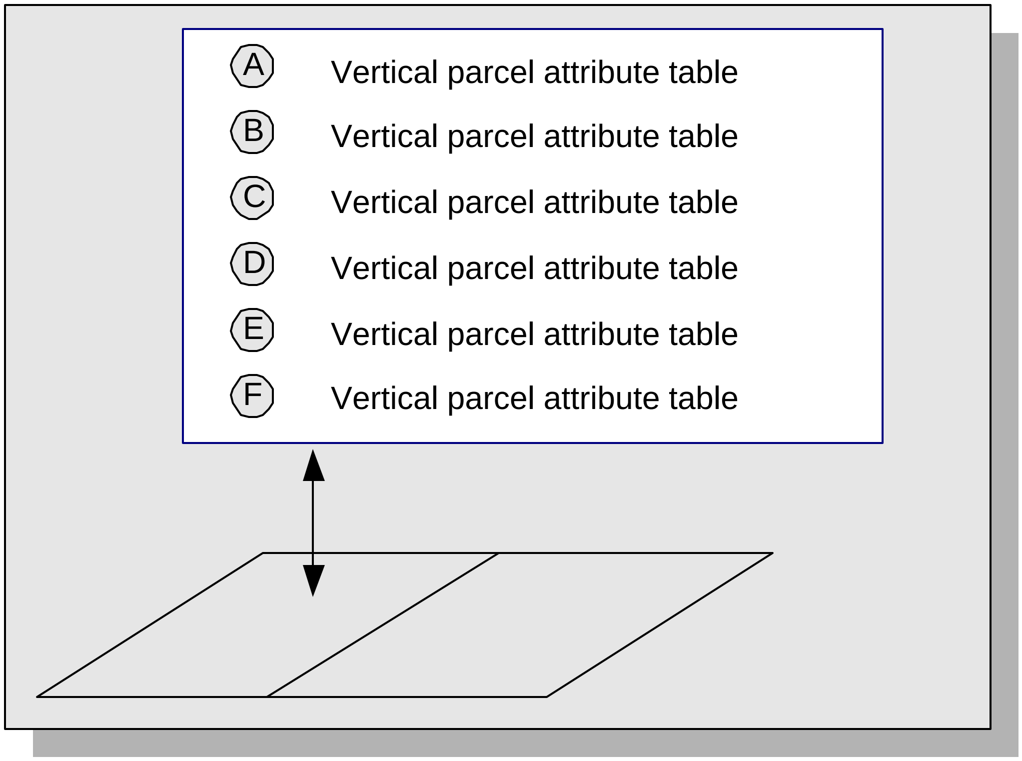


Figure 3 – Condominium Polygon Pointing to a Table

The second approach is to have the polygon outline in the ownership object that points to or is related to another series of polygon objects. Each related polygon represents a layer or floor of the condominium with the individual owners and common elements indicated. Figure 4 illustrates this approach. In Figure 4 there are three polygons related to the outline polygon. Each of these is a level or floor. The area owned by owner F is indicated in each level polygon and there is an accompanying table that can either summarize all of the holdings of owner F or a table can be attached to each level polygon that describes the owner on each floor.

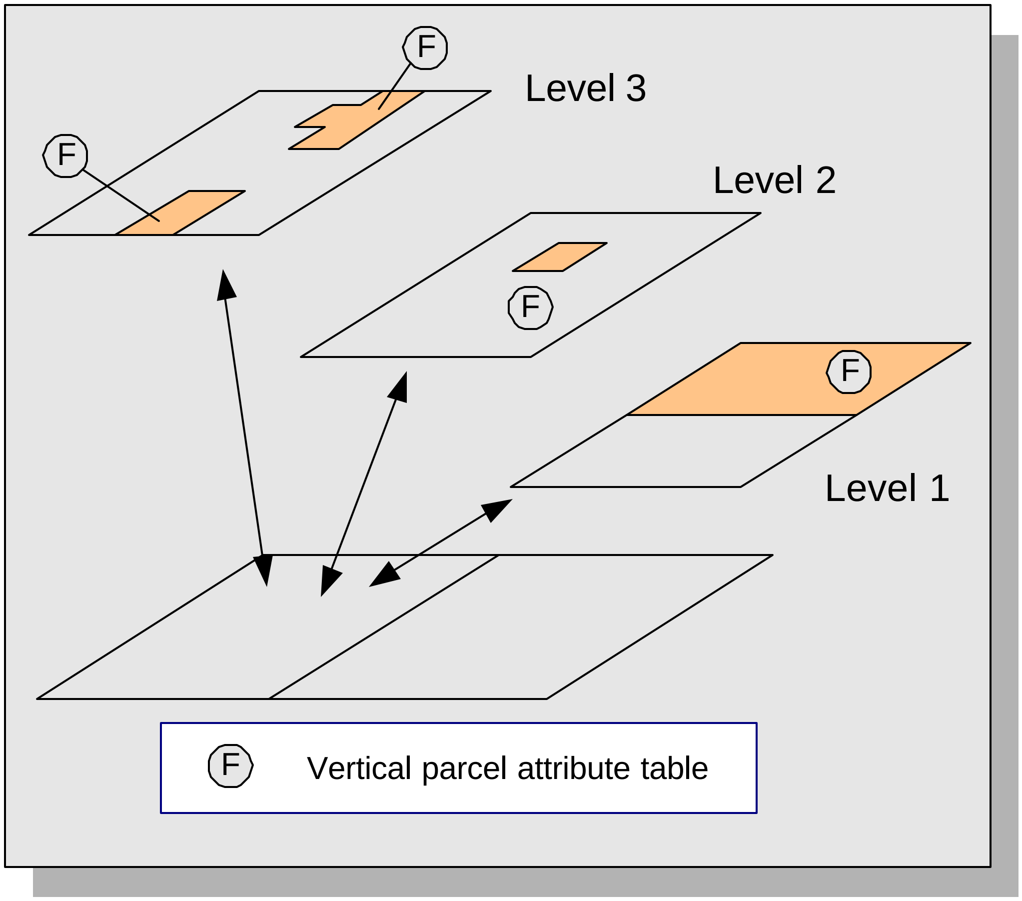


Figure 4 – Condominium Polygon Pointing to Floor Polygons

The third scenario is to have a three dimensional model of the building. This is a more complex approach and a three dimensional model of the building is required. However, like the first two approaches the three dimensional model would be related to the ownership parcels through the condominium outline polygon.

In many jurisdictions the values and assessments of the common elements are prorated over the individual ownership parcels in the condominium, but common elements may also be mapped, assessed, and managed separately. Common elements may be assigned to the condominium the owners as a group, the condominium association, a developer that is managing the common elements, or the common elements may be exempt from assessment and taxes.

In the ownership parcel polygons, the exterior of the condominium is shown on the parcel map with a polygon type indicating that it is a vertical parcel. The exterior or outline polygon meets the requirements of the ownership features.

3.2 Encumbrances

Encumbrances are limitations on the rights and use of the land. Easements are a common encumbrance but there are many others such as grazing rights, fishing rights, development rights, and hunting rights. Legally an encumbrance is a right or interest in the land of another that may diminish its value but does not prevent its sale.

Some encumbrances run with the land. That is they are tied to the land and will persist from owner to owner. Others exist at the pleasure of the owner and do not run with the land. These encumbrances expire and return to the original owner when land is transferred.

For the purposes of this discussion encumbrances are not part of the ownership parcels. They can have their own legal description, can be overlapping, and are non-continuous.

The *Encumbrance* feature is an interpretation of the rights and interests in land. The *Encumbrance* feature class is characterized as:

- Overlapping – Rights can overlap. For example ingress/egress of an easement, a prescriptive right of way and a land grazing lease can all overlap.

- Non-continuous – There are many areas of land that are free from encumbrances.

Figure 5 illustrates a fee simple parcel with a grazing lease across the entire parcel and a right of way for ingress and egress across a portion of the parcel. Encumbrances overlap as shown and are non-continuous as described above.

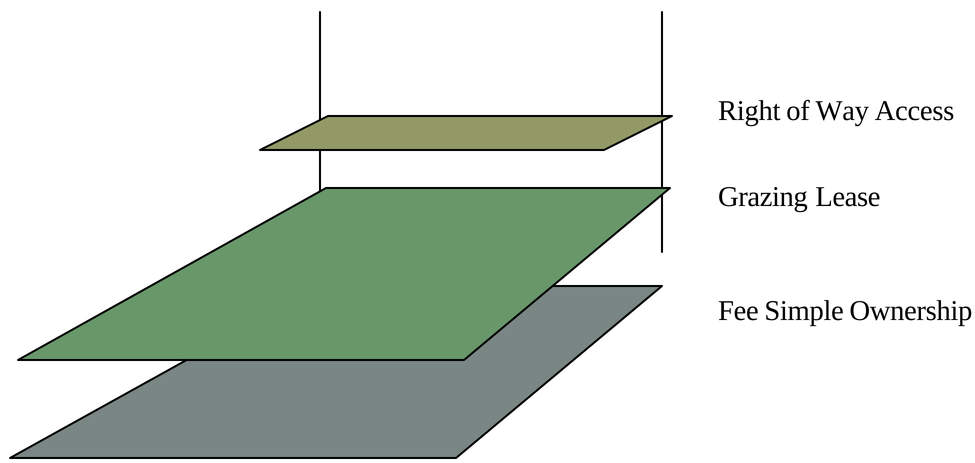


Figure 5 – Example of Encumbrances

The question of whether roads are an encumbrance or a fee simple interest varies from jurisdiction to jurisdiction. For example, Brown (1995) defines a prescription (prescriptive easement) as the acquisition of an easement by adverse use under claim of right for the statutory period required by law. It can be thought of as adverse possession applied to easements. In many states prescriptive easements are a specified width such as 4 rods (66 feet). In these cases the description of the fee simple parcel may extend to the center of the prescriptive a right of way, but the public controls the use of land in the prescriptive easement. That is, the owner of the parcel does not have the right of enjoyment of the land in the prescriptive area. The owner may have future reversion rights if the right of way is abandoned. Figure 6 illustrates another case of reversion rights.

Figure 6 – Reversion Rights

The right of way in the picture above ends in a cul-de-sac. Parcels on either side have land in the right of way. When the right of way is abandoned, the ownership of the land reverts to the adjoining parcels, as shown in the bottom diagram. While the aright of way was being used as a road, it was exempt from property taxes and was shown as right of way. Once it was abandoned and reverted to the adjoining owners, the land was put back on the tax roll.

Should prescriptive areas be shown as publicly held parcels in the ownership parcels or should the underlying owner be shown with the prescriptive right or reversion right shown as an easement? The object model can handle either scenario and it would be up to each jurisdiction to decide how they would map and manage prescriptive easements and reversion rights. If the prescriptive areas are separate ownership, then the ownership representation is continuous. If the underlying landowner is shown as holding the land with an easement on top, the ownership is still represented as continuous polygon features with encumbrances to represent the full picture. The differences will be in the processes applied to determine the tax parcel and in how related tables and relationships are connected to the objects.

3.3 Separated Rights

The separated rights are rights and interests in land ownership that can be disconnected from the primary or fee simple surface ownership. For example, mineral and oil rights are often separated from the surface ownership. Separated rights are represented as overlapping polygons. The ownership parcels represent the non-overlapping fee simple surface estate. The separated rights are modeled similarly to encumbrances. Some of the idiosyncrasies of separated rights are:

- There are often future estates and leases associated with minerals. In these cases the mineral rights may be separated from the surface for a period of time.
- The mineral rights can be divided according to the mineral. For example, fossil fuels, oil and gas, sulfite minerals and surface quarry rock are often considered as distinct separated rights. In these cases separated rights are overlapping and non-continuous.
- The apex rule for minerals that are found as defined veins and are claimed under the 1872 mining claims act provides for extralateral rights. This means that who ever claims the surface expression of a veined mineral deposit has the rights to the mineral deposit even though it may pass under the land of adjoiners. This is shown in Figure 7.

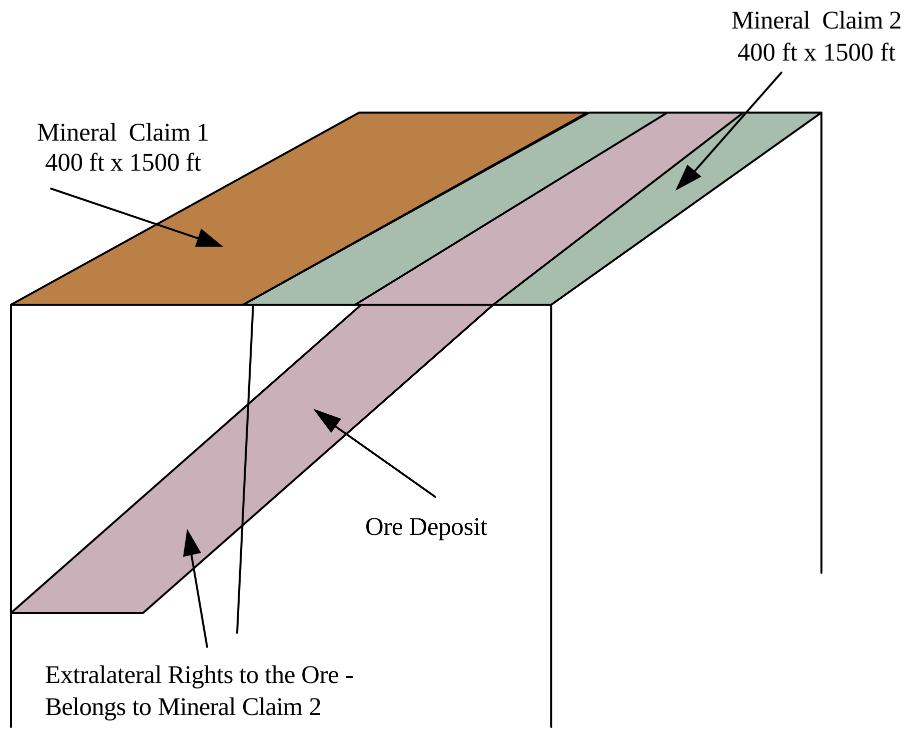


Figure 7 - Apex Rule for Mineral Claims

There are also above ground separated rights. The above ground separated rights include things like solar easements and transferable development rights (TDRs). These too are potentially overlapping and non-continuous polygons. Overhead or above ground separated rights tend to be three dimensional "envelopes" although they can be expressed with a flat or two dimensional expression.

The separated rights are modeled as their own feature and are polygons. As with the vertical parcels there could be a series of polygons based on mineral type, based on type of mineral claim such as *lode*, which is a mineral that is in place and generally in a vein, or *placer*, which is all forms of mineral deposits that are not in place and are generally minerals in a loose state, or any other classification.

3.4 Ownership Parcel Features

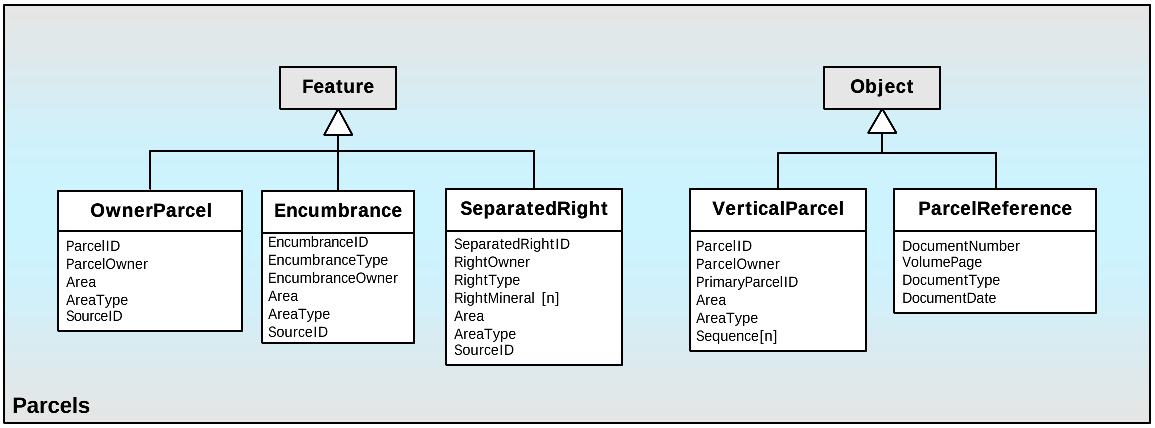


Figure 8– Parcel Objects

3.5 Historical Parcels

Parcel information is outdated as soon as it is collected. Real estate transactions, parcel splits, and new subdivisions occur almost continuously. Some jurisdictions may keep the most current representation of ownership parcels and are not be concerned with past representations. Others may keep timed or periodic snap shots, such as monthly, quarterly, or yearly views of parcel information as it existed at that time. Still others track the transactional changes and maintain a record of all changes in ownership and geometry. The historical information and lineage is tracked as a version change in the ArcGIS technology. This section describes the functionality and requirements for historical parcel information management and some options with the ArcGIS Parcel Data Model for this functionality. Three types of historical parcels are described, archive, periodic, and transactional.

Archive

This type of historical information is a snap shot of the entire geodatabase at a point in time. Local governments often do this once each year to document and archive the tax roll or assessment roll as it exists at the end of the tax or assessment cycle. Over time these yearly or regular archives can be analyzed for changes in assessment patterns and can be used to document the conditions or state of data at a point in time. Typically this type of historical parcel information does not track intermediate changes that occur between archive periods. For example, a property could change hands several times during the year and only the starting and ending owner would be captured in the archive. Figure 9 illustrates an archive example.

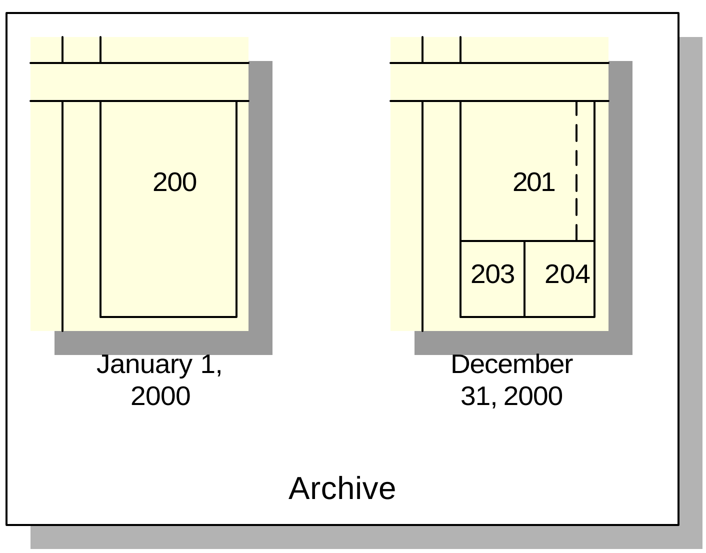


Figure 9 – Archive Historical Parcels

Periodic

Periodic historical information documents the changes from a known point in time. These are versions that contain only changes. This is sometimes called a working file in local governments and may, for example, contain the parcel and assessment changes from the beginning of the year. The changes may then be kept as a separate archive at the end of the year or may be combined with the information that didn't change and combined into a new end of year version. If the periodic changes are kept as a separate file there is a record of the intermediate updates and changes during the year.

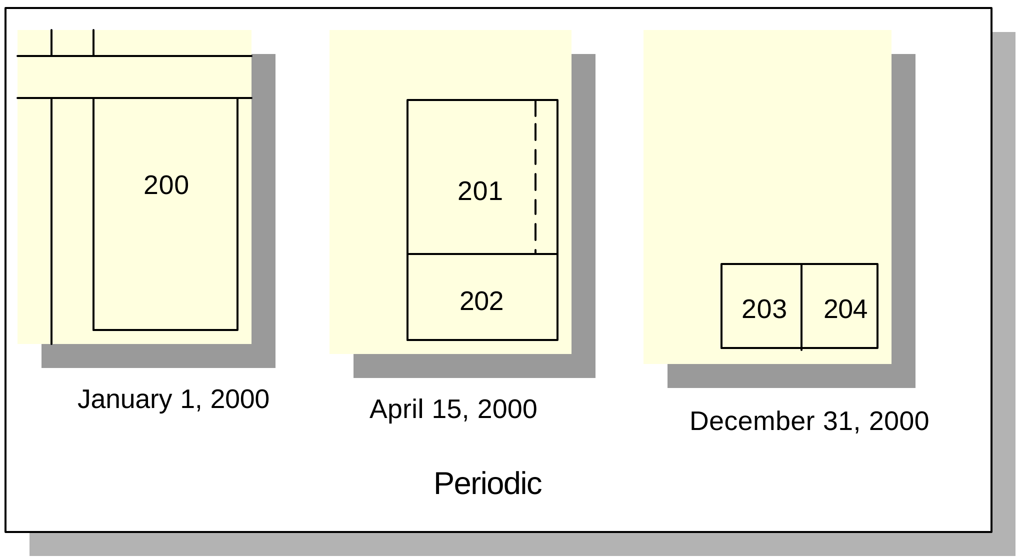


Figure 10 – Periodic Historical Parcels

This approach, shown in Figure 10, supports spatially enabling the assessment roll. The periodic archive may not be fully reconciled, i.e. intermediate parcels may not have complete object attributes and information.

Transactional

This type of historical information tracks and keeps all transactions and all history of parcel information. All changes are kept in a timed sequence and all changes are kept and maintained. Transactional historical information keeps the chain of title as well as geometry changes. The current ownership is captured determined from the most recent set of transactions.

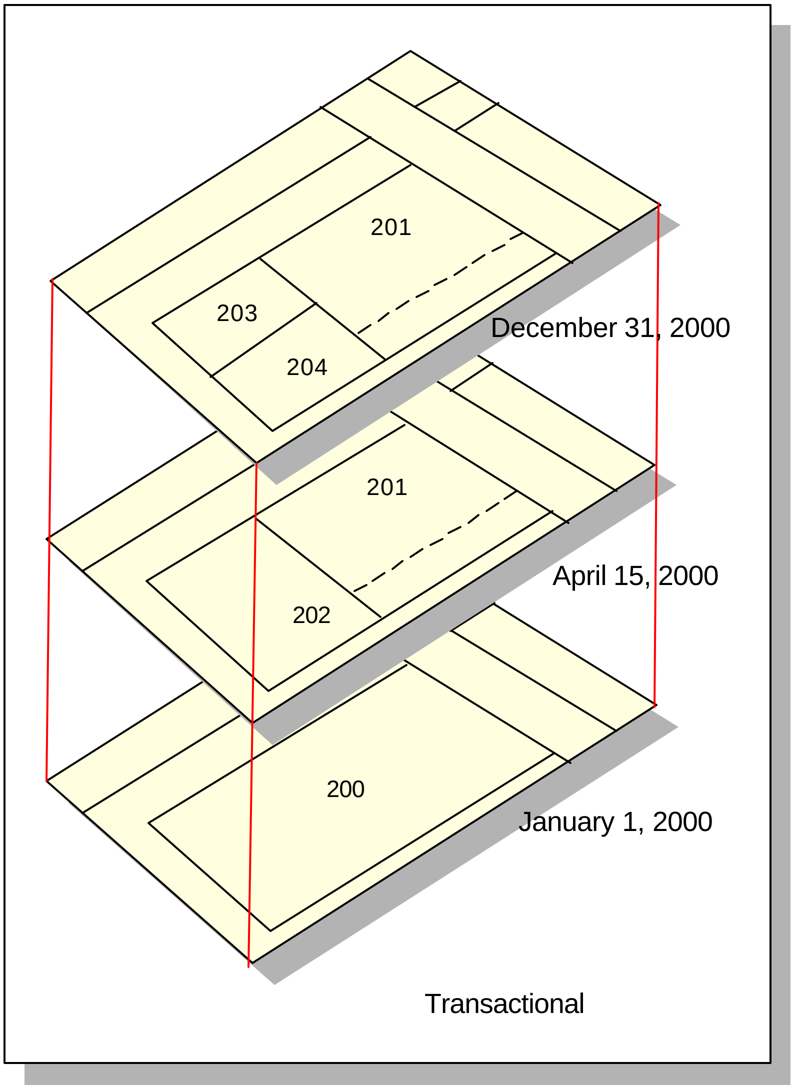


Figure 11 – Transactional Historical Parcels

This type of historical parcel management supports spatially enabling a title or land ownership transactional system and a transactional document imaging system. It leads to a full reconciliation with all aspects of the life of the parcel.

4. Survey Frameworks

Survey frameworks are a higher-level structure for ownership parcels, for example a subdivision exterior boundary defines and contains the individual ownership lots within the subdivision. Typically the subdivision boundary is senior to the lot boundaries with in it. The Survey Framework features are the first or upper levels of a nested hierarchy for describing land ownership. These are all polygon features. Survey Frameworks have the following characteristics.

- Surveyed and measured
- Form a framework of senior boundaries or structures for describing ownership, and
- They form closed polygons

The two survey frameworks described here are simultaneous conveyances and the Public Land Survey System (PLSS). Offshore survey frameworks, French claims and Georgia Military Districts are examples of other Survey Frameworks that can be deployed similarly to the features described here. That is, there are many types of survey systems that form hierarchical frameworks for describing land ownership. The two described here are the most commonly occurring.

4.1 Simultaneous Conveyances

Simultaneous conveyances occur when several parcels are created at the same moment such as lots in a subdivision, units in a condominium, or plots in a cemetery.

> *A simultaneously created boundary results when several parcels of land are created in the same legal instant by the same person, persons, or agency and by the same instrument. All parcels have equal standard and no such portion can be said to have prior rights or seniority over any other portion.*

Brown, 1995, page 295

Some texts describe public land survey system (PLSS) townships as simultaneous conveyances, but they are modeled separately in the parcel data model because the hierarchical structure has special rules for the PLSS. See the Section 4.2 for the PLSS features.

State laws control simultaneous conveyance rules and definitions. However, there are some commonalities. For example,

1. Many simultaneous conveyances have a hierarchical structure such as the exterior boundary is senior to interior lines,
2. Lots may be nested inside blocks, and
3. Dedicated rights of way may be exempt from proportional measurements, i.e. their width is maintained.

For the purposes of the ArcGIS Parcel Data Model the simultaneous conveyance feature class has a polygon for the external boundary of the conveyance, such as the subdivision exterior, and a nested or hierarchical polygon feature class that is contained within the simultaneous conveyance, which could be roads, blocks or other feature type.

One purpose of the simultaneous conveyance feature is to improve polygon rendering. For example the external boundaries of plats may be shown with a heavier weight line or they may be annotated differently. Another purpose of the simultaneous conveyance features is to provide a structure to parcel descriptions in the ownership feature class. For example, in the Arc/Info 7.x and earlier technologies, many jurisdictions used a region structure for plats and subdivisions. It also allows the parcel map to be related to underlying lots from which a parcel description is derived.

The simultaneous conveyance features support the ownership parcel feature class. Conceptually these features are non-overlapping. This means that plats and subdivisions may appear to overlap because of discrepancies in measurements, but in fact one or the other will control. It may not be apparent which controls without a ground survey. Therefore, the simultaneous conveyance features are overlapping polygons that are non-continuous. That is, the entire jurisdiction may not be covered by simultaneous conveyances and they may appear to overlap.

In Figure 12, the parcels from Figure 1 are shown within two adjoining simultaneous descriptions.

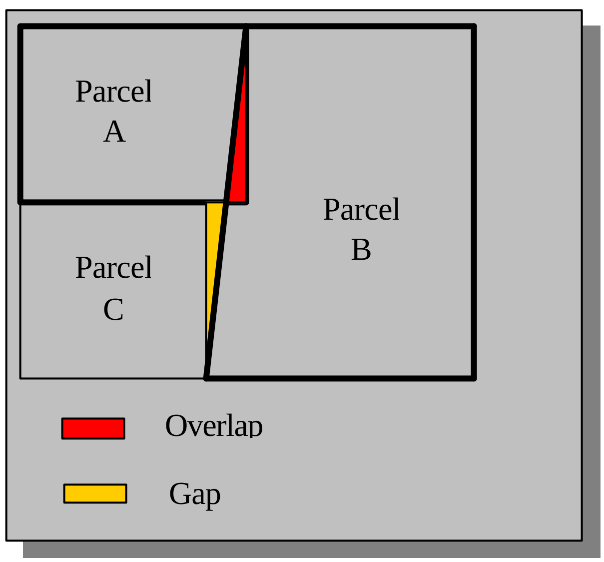


Figure 12 – Simultaneous Conveyance Overlap

In the example in Figure 11, Parcel B is a lot in Happy Acres Subdivision and Parcel A is a lot in Unhappy Acres Subdivision. The two subdivision exterior lines are shown with a heavier weigh line. The ownership parcels remain as they did in Figure 1, but either a digital or visual inspection allows users to ascertain the extent of the plat boundaries.

Figure 13 is an image of a subdivision plat. This is a typical simultaneous conveyance. The red line on the image is the external subdivision polygon feature. The blue lines are two blocks within the subdivision, which would be the polygons for the first division feature class. The first division polygons are non-overlapping and are contained entirely within the subdivision. The first division polygons are not continuous because, as shown in Figure 13, a road right of way separates the two blocks. The second division polygons are the individual lots within the blocks. They are contained entirely within the block boundaries and are also non-overlapping by definition and may be non-continuous.

There is an important difference in the way some organizations manage conveyances from the example above. It is often the intent of subdivision platting statutes to provide a legal description of all lands contained within the subdivision. If this applies, then the more strict continuous polygon rule can be applied to the first and second divisions.

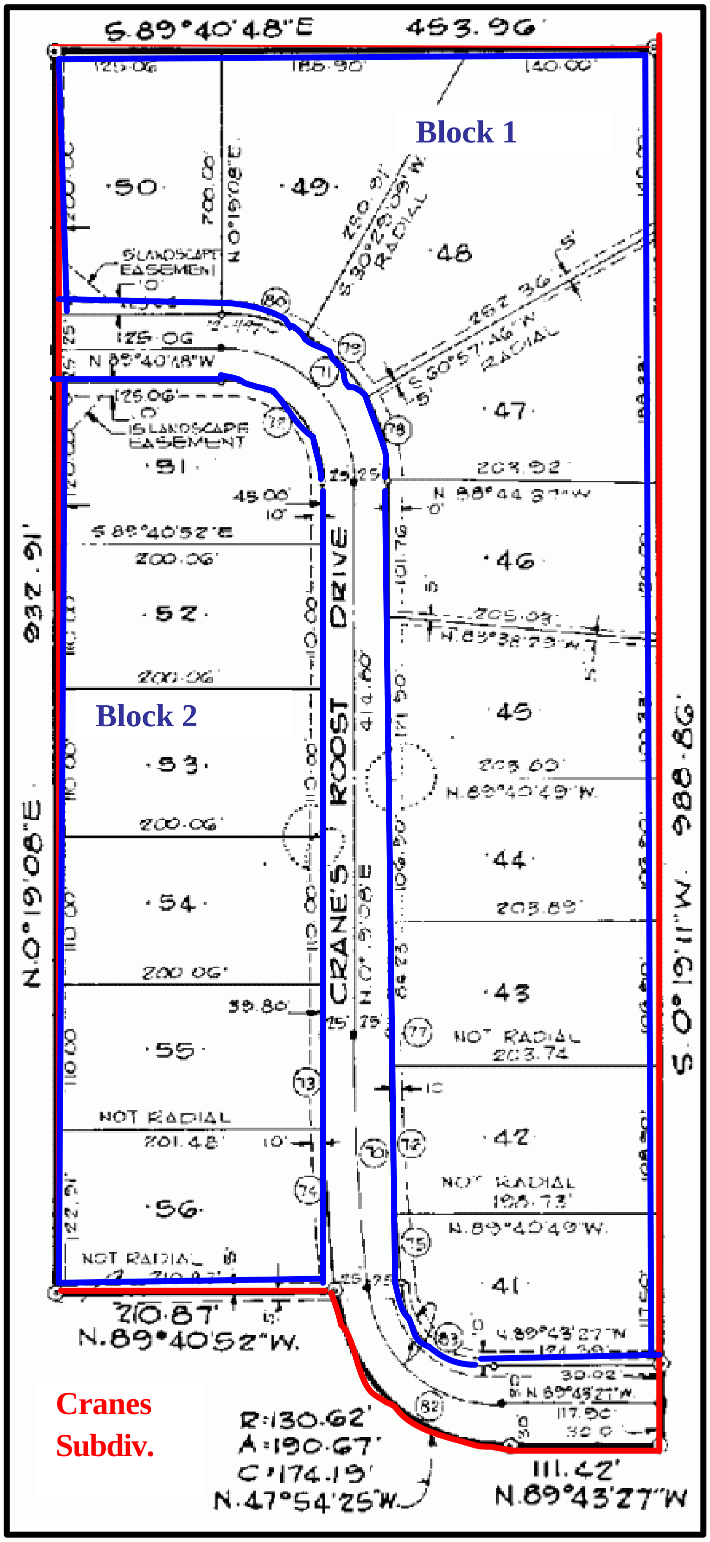


Figure 13 – Subdivision Plat

4.2 Public Land Survey System

The Public Land Survey System is a hierarchical group of feature classes that define the current state of land descriptions within the PLSS.

The Public Land Survey System (PLSS) is a set of baselines and principal meridians that define more or less rectangular divisions of land. It originated in the 1780's as a system for inventorying and describing the public domain. It remains as the prevalent legal description framework in 32 states today.

In its idealized form, rectangular divisions begin with six mile by six mile Townships that are numbered north and south of baselines and east and west from principal meridians. To account for the convergence of meridians, east-west correction lines are established at regular intervals. Townships nominally are divided into 36 sections each being nominally one mile by one mile. The Townships can be divided into sections, tracts, lots and other types of divisions. If the first division is sections these can be further divided into aliquot parts by quartering and lotting the sections. The PLSS nested feature classes are the polygon manifestations of the PLSS descriptions.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Figure 14 - PLSS Township Section Divisions

Figure 14 illustrates the normal Township section divisions with the sections numbered. However there are exceptions to this rule all across the public domain states. The Township in Figure 14 is rectangular, but this is a generalization.

The nested components of the PLSS are described in the Cadastral Data Content Standard (FGDC, 1999). The PLSS Township is the first or top level of polygon in the public land survey system. Principal Meridian and/or Baseline identify PLSS Townships. If the division is not PLSS Township then there is a Survey Name and potentially a Secondary Survey Name. The Survey Name and Secondary Survey Name generally occurs in Ohio, the testing ground of the public land survey.

The first division of the PLSS Township, as defined in the Cadastral Data Content Standard, is the division of the nominal six mile by six mile Township areas. Townships are most commonly divided into sections, but can also be divided into tracts, protraction blocks and other divisions. The first divisions of the Townships are non-overlapping and more than one type of first division can exist in a PLSS Township.

The second division of the PLSS Township, as defined in the Cadastral Data Content Standard, is a division of the first division. The most common second division divides a section into *aliquot parts*, which are divisions formed by halving and quartering, however second divisions can include government lots and tracts. Figure 15 is an example section divided into quarters and one quarter divided into sixteenths.

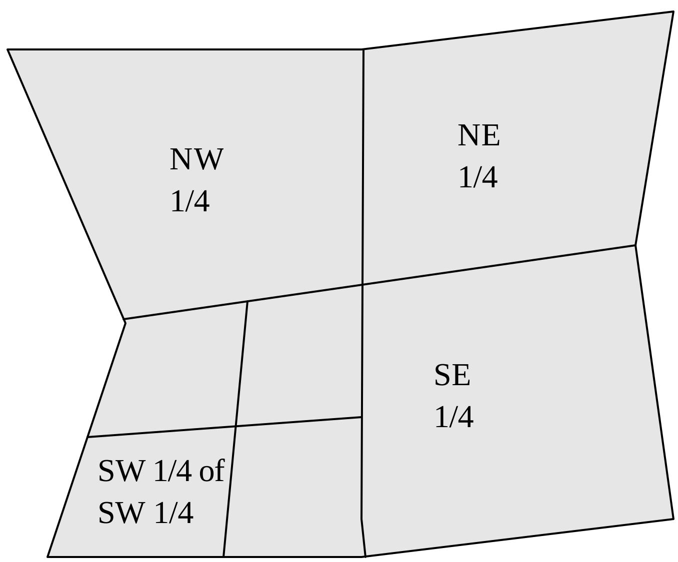


Figure 15 – Public Land Survey System Second Division

The reason the quarter and sixteenth parts are included in the second division is that these are commonly occurring divisions and they are non-overlapping. Typically all divisions of the section are defined, even if they are not staked or described, once the center of section is established.

4.3 Feature Classes

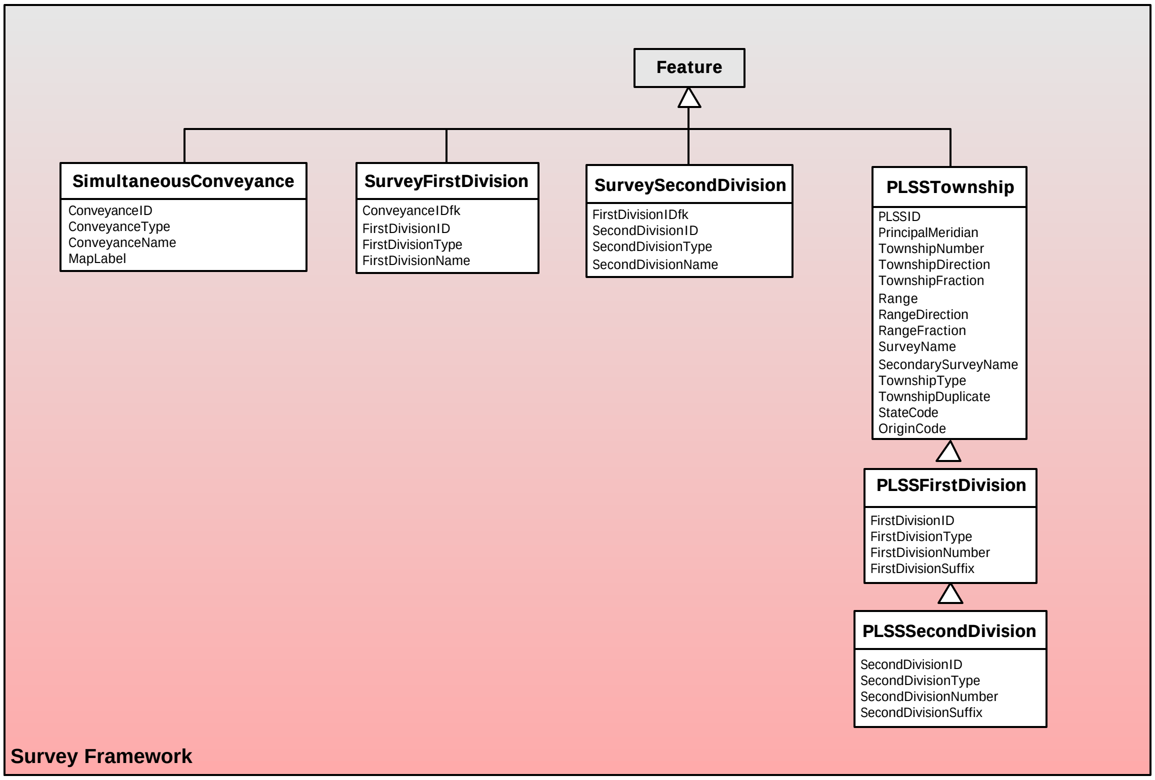


Figure 16 – Survey Frameworks

5. Tax Parcels

Tax parcels arise from the real property tax systems, where land is valued, assessed and taxed to support government functions. In many local jurisdictions tax parcel mapping is the driving function for parcel automation. Tax parcel management can be considered in five stages:

- Assessment,
- Equalization,
- Taxation,
- Tax Mapping, and
- Archive

This discussions looks at tax assessment, where values are established, tax billing, where property bills are generated from the values, and the tax mapping, which is the parcel mapping for the assessment or tax parcels.

Equalization is a highly variable process that can be done by local, county, or state jurisdictions and is not discussed here. Equalization is an adjustment of the assessed values to balance inequities that may occur across a county or a state. Sometimes equalization factors are applied to reach a percentage of true market value. They can also be applied to specific use classifications, such as manufacturing. Not all real property tax systems have an equalization component.

Archiving is the process of storing historical information. Nearly all property tax applications require a means to retrieve historical versions of tax information. The historical tax parcels provide a graphic representation of past assessment rolls, assist assessors with making value determinations on new parcels, and support many other trend and analysis functions. Managing historical parcel information is an important part of any parcel mapping system. Section 3.5 discusses the approaches to archiving and other historical parcel management.

5.1 Tax Assessment

The purpose of tax assessment is to establish the values on real estate for property taxing. Parcel assessment generally occurs in five steps.

- Discover taxable real estate
- Value taxable real estate
- Classify taxable real estate according to use or other basis
- Designate value for exempt real estate
- List values and use on an assessment roll

The specific steps for assessment varies from state to state and from jurisdiction to jurisdiction, but these five steps are generic characterizations of the assessment process.

One notable exception to this process is that some jurisdictions do not value and classify exempt lands.

Tax assessment classifications may apply to and be coincident with the boundaries of the ownership parcel. In these cases the tax assessment classification may be an attribute of the ownership parcel. In other cases a single ownership parcel may have multiple tax assessment classifications. The tax assessor may define the boundaries of assessment classifications areas or they may be defined in terms of a percentage of the area of an ownership parcel.

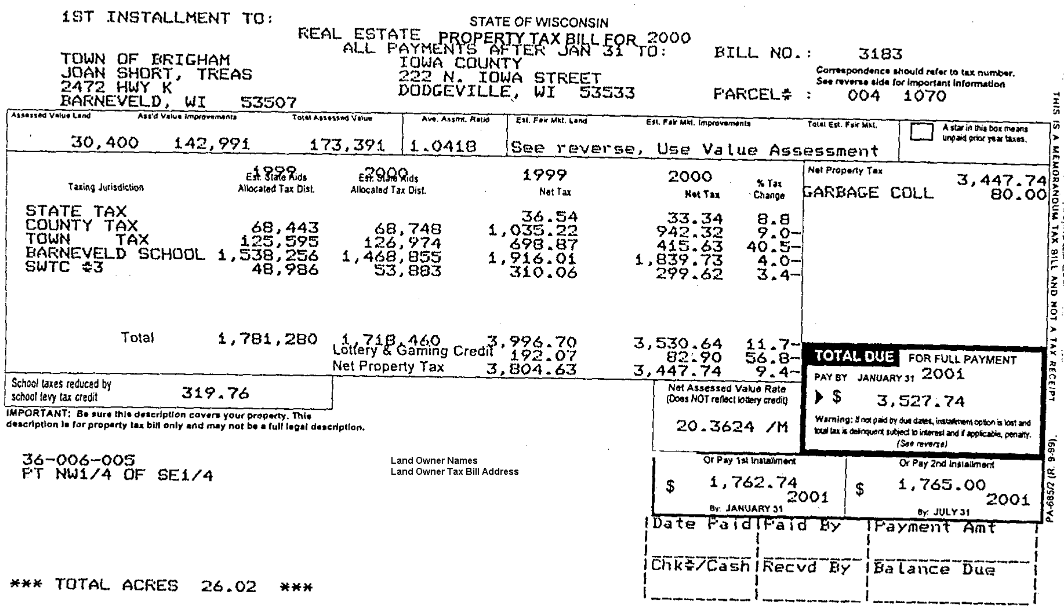
Tax assessment classifications could be defined a separate polygons. These are sometimes called *sub-parcel* areas. This means that the classifications can further divide the ownership parcel and be related to elements the assessment roll. This would mean that the sub-parcel polygons would be *assessment parcels* or *assessment areas* and would be managed within the tax parcel mapping.

5.2 Tax Bills

Tax bills are the result of the assessment information combined with a budget or other financial information to produce the taxes owed for each taxable parcel in a jurisdiction. Tax bill computation can be done in a number of ways. One approach is as follows.

- Snap shot the assessment roll at a statutorily defined point in time
- Total all the taxable value for the roll
- Compute a mil rate (dollars of tax owed per 1000 dollars of value) by dividing the total value into the total dollars of real estate tax that must be raised
- Apply the mil rate to the taxable lands
- Compute credits (such as lottery, other tax, programs)
- Generate and mail tax bills
- Collect taxes and track non-tax payments

Figure 17 is an example of a property tax bill.



1ST INSTALLMENT TO:

STATE OF WISCONSIN
REAL ESTATE PROPERTY TAX BILL FOR 2000
ALL PAYMENTS AFTER JAN 31 TO:

TOWN OF BRIGHAM
JOAN SHORT, TREAS
2472 HWY K
BARNEVELD, WI 53507

IOWA COUNTY
222 N. IOWA STREET
DODGEVILLE, WI 53533

BILL NO.: 3183
Correspondence should refer to tax number.
See reverse side for important information
PARCEL# : 004 1070

Assessed Value Land	Ass'd Value Improvements	Total Assessed Value	Ave. Assmt. Ratio	Est. Fair Mkt. Land	Est. Fair Mkt. Improvements	Total Est. Fair Mkt.	A star in this box means unpaid prior year taxes.
30,400	142,991	173,391	1.0418	See reverse, Use Value Assessment			

Taxing Jurisdiction	1999 Est. State Aids Allocated Tax Dist.	2000 Est. State Aids Allocated Tax Dist.	1999 Net Tax	2000 Net Tax	% Tax Change
STATE TAX			36.54	33.34	8.8
COUNTY TAX	68,443	68,748	1,035.22	942.32	9.0-
TOWN TAX	125,595	126,974	698.87	415.63	40.5-
BARNEVELD SCHOOL	1,538,256	1,468,855	1,916.01	1,839.73	4.0-
SWTC #3	48,986	53,883	310.06	299.62	3.4-
Total	1,781,280	1,718,460	3,996.70	3,530.64	11.7-
		Lottery & Gaming Credit	192.07	82.90	56.8-
		Net Property Tax	3,804.63	3,447.74	9.4-

Net Property Tax 3,447.74
GARBAGE COLL 80.00

School taxes reduced by school levy tax credit 319.76

IMPORTANT: Be sure this description covers your property. This description is for property tax bill only and may not be a full legal description.

Net Assessed Value Rate (Does NOT reflect lottery credit) 20.3624 /M

TOTAL DUE FOR FULL PAYMENT
PAY BY JANUARY 31 2001
$ 3,527.74
Warning: If not paid by due dates, installment option is lost and total tax is delinquent subject to interest and if applicable, penalty. (See reverse)

36-006-005
PT NW1/4 OF SE1/4

Land Owner Names
Land Owner Tax Bill Address

Or Pay 1st Installment $ 1,762.74 By: JANUARY 31 2001
Or Pay 2nd Installment $ 1,765.00 By: JULY 31 2001

Date Paid	Paid By	Payment Amt
Chk#/Cash	Recvd By	Balance Due

*** TOTAL ACRES 26.02 ***

THIS IS A MEMORANDUM TAX BILL AND NOT A TAX RECEIPT
PA-685/2 (R. 9-99)

Figure 17 – Sample Property Tax Bill

5.3 Tax Maps

The mapping component is usually an optional component in terms of statutes and ordinances. The certification and licensure of who can do tax mapping varies widely from state to state. The intent of most tax parcel mapping is to represent graphically all lands that have an entry on the assessment roll. The tax mapping may or may not include exempt lands.

The ArcGIS Parcel Data Model supports the tax parcel mapping component of the property taxing process. Figure 18 is a tax parcel map for the parcel and the area surrounding the tax parcel shown on the tax bill in Figure 17.

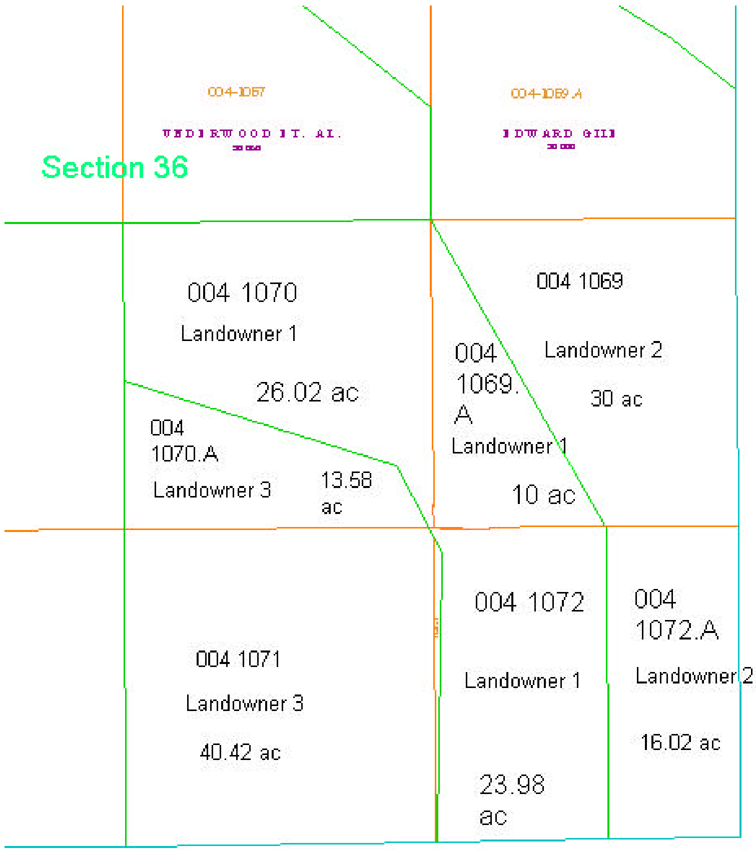


Figure 18 – Sample Tax Map

In Figure 18, the ownership parcel for landowner 1, which has been captured as an interpreted ownership parcel, is further divided into three tax parcels (004 1070, 004 1069.A, and 004 1072). The divisions of the Public Land Survey System were used to generate the three tax parcels.

Figure 19 illustrates some of the local decisions that are made regarding combining and splitting ownership parcels to form tax parcels. In Figure 19 another portion of a the tax map from the same jurisdiction as Figure 18 illustrates two ownership parcels. In this case the Owner 1's parcel is divided into three tax parcels. The map hooks indicate ownership crossing a Public Land Survey System Township line. Certified Survey Map (CSM) number 494 as annotated describes the ownership on the tax map. The right of way polygon along the left side of the parcel is part of tax parcel 004 680.A.

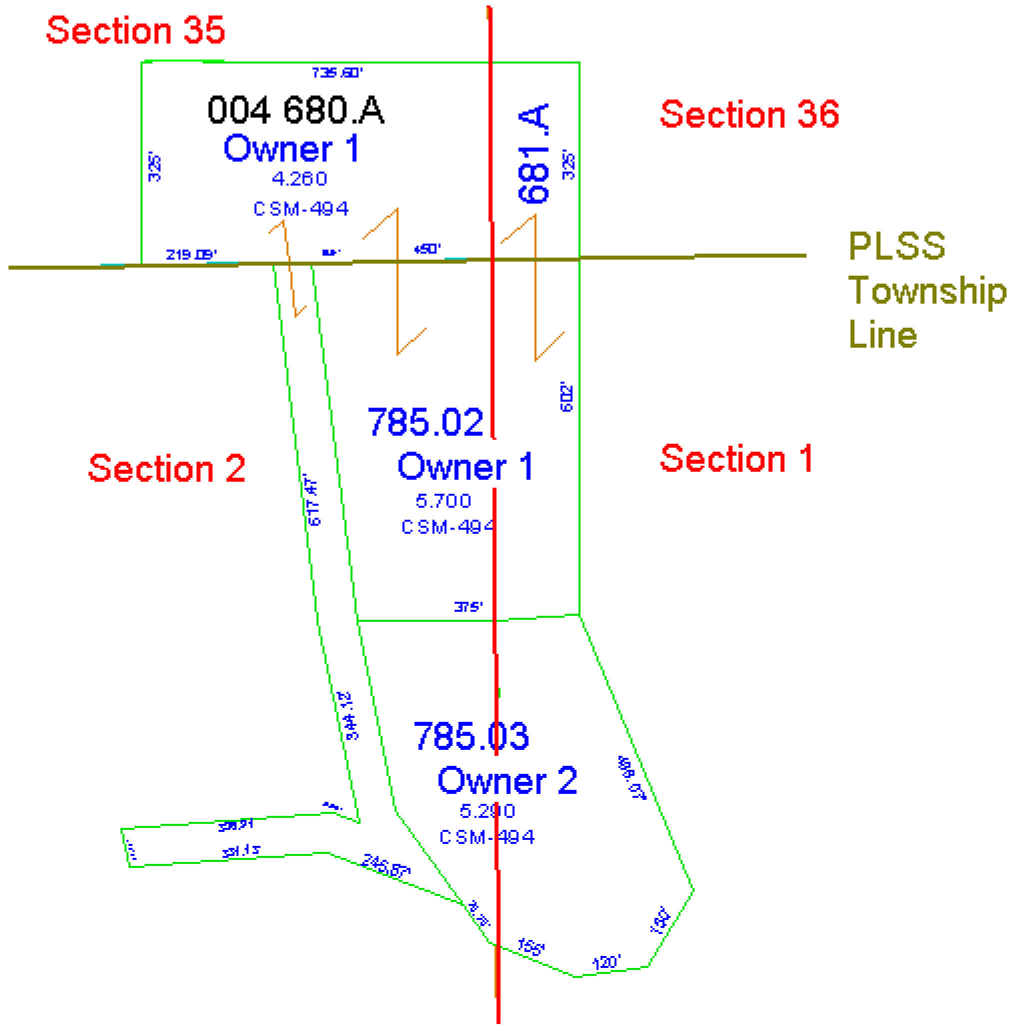


Figure 19 – Tax Parcels and Ownership Parcels

Figure 20 illustrates the non-continuous nature of some tax parcel mapping. In this figure, the area shaded in gray in the lower left is owned by a non-taxable entity, the village, and the grayed out area in the upper right is a road right of way. The external boundary of the area is mapped, but no parcel numbers are assigned to shaded areas. In this approach the sum of the area of the tax maps will not be the total area within the jurisdiction. But because the area in gray is not of interest to the assessment and property tax functions, the tax parcels are not maintained.

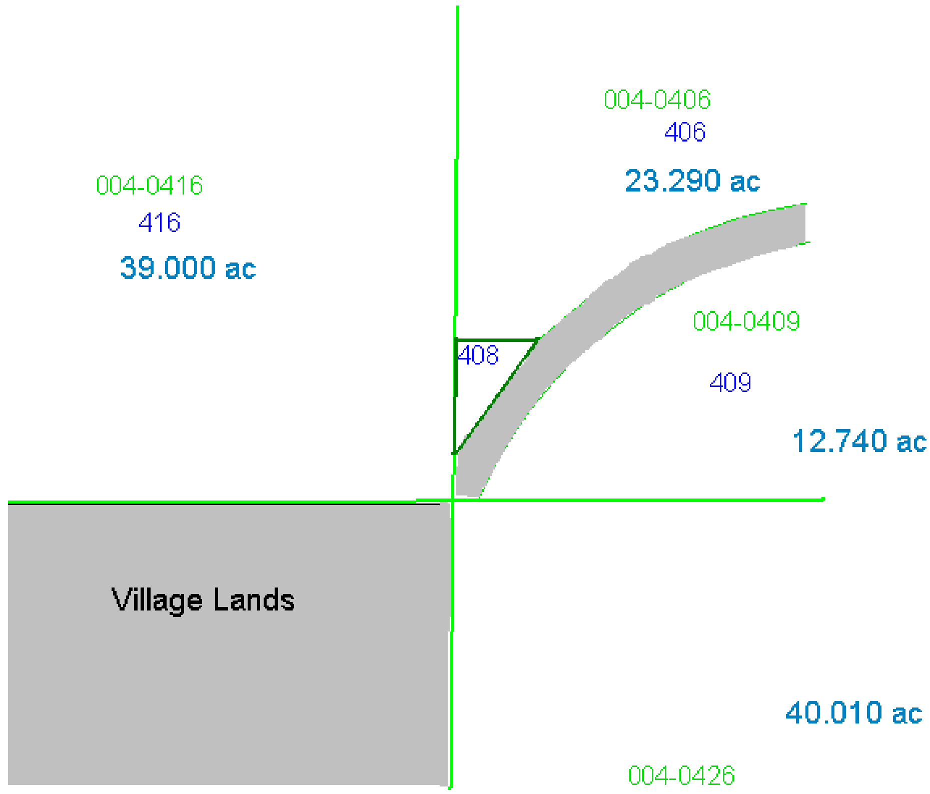


Figure 20 – Exempt Lands

There are many variations of tax mapping across the country including various rules for including or excluding parcels, for dividing or combining ownership parcels, and presentation in terms of annotation and line work.

5.4 Features Classes

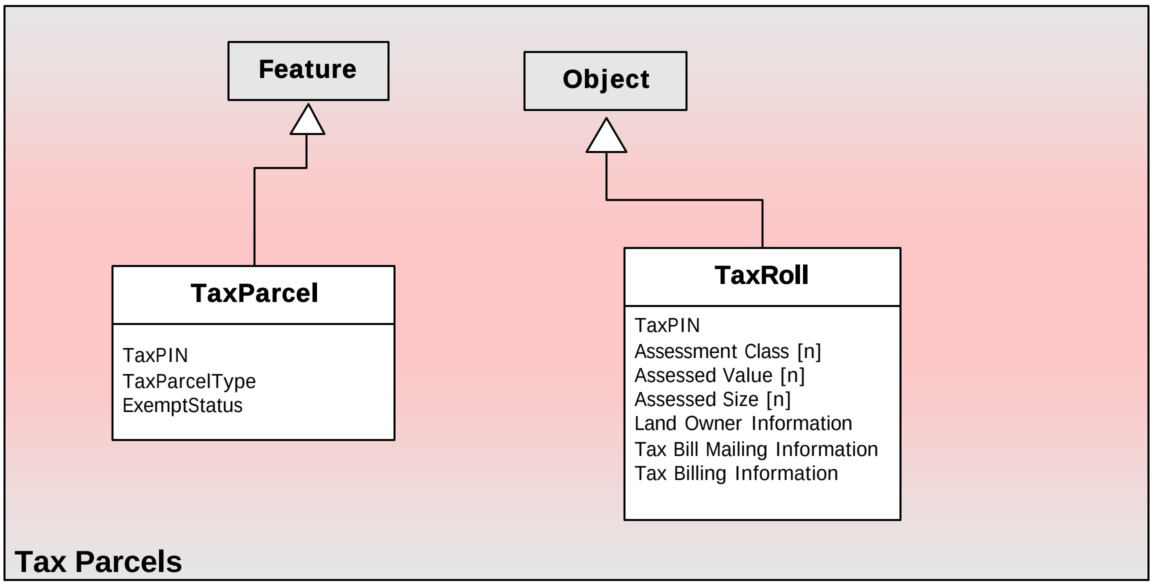


Figure 21 – Tax Parcels

6. Related Uses for Parcel Information

Related uses for parcel information describe business areas or functions that apply the parcel information to meet specified needs. The parcel definition and the rules for building and updating the parcels are often based on a business or application need. The parcel uses may be a subset of ownership parcels, for example a selection from the ownership parcels of all taxable land. Related parcel uses may also divide the ownership parcels into smaller areas; for example, a single ownership parcel may be divided into two use restrictions or have multiple site addresses. Ownership parcels may be combined to form application parcels. For example, a single zoning district may be comprised of all the parcels in an area with the same zoning classification, such as single family residential or commercial.

The number of parcel uses is nearly limitless. Three examples are included in this discussion.

- Site Addressing
- Regulated Uses and Restrictions
- Administrative Boundaries

Data Models are not included for these uses.

6.1 Site Addressing

Site addresses are the location addresses of a parcel. Site address points are coordinated values that are in or near a parcel and serve as a location for the site address information. Maps and representation of parcel information through an address point can serve as a rapid development and automation of parcel information and it can serve many departments.

Site address points are a geo-location for a site address. Most site addresses are assigned to structures. For example a building may have one site address that can span multiple parcels, or parcel may not have a site address, such as vacant land, or a parcel could have multiple site addresses, such as parcel with many buildings or businesses.

For some applications there may also be important supplemental address points. For example, in rural environments there may be related points that identify the end of the driveway for emergency vehicles. In urban environments there may be points that identify entrances to and turns on major roads to gain access to the parcel. These related points are not included in the ArcGIS Parcel Data Model design but it is recognized that these can be important points.

Figure 22 illustrates structures on parcels with site address points. Parcel information can be linked to the site address point. The structures may have more than one address, as in the condominiums.

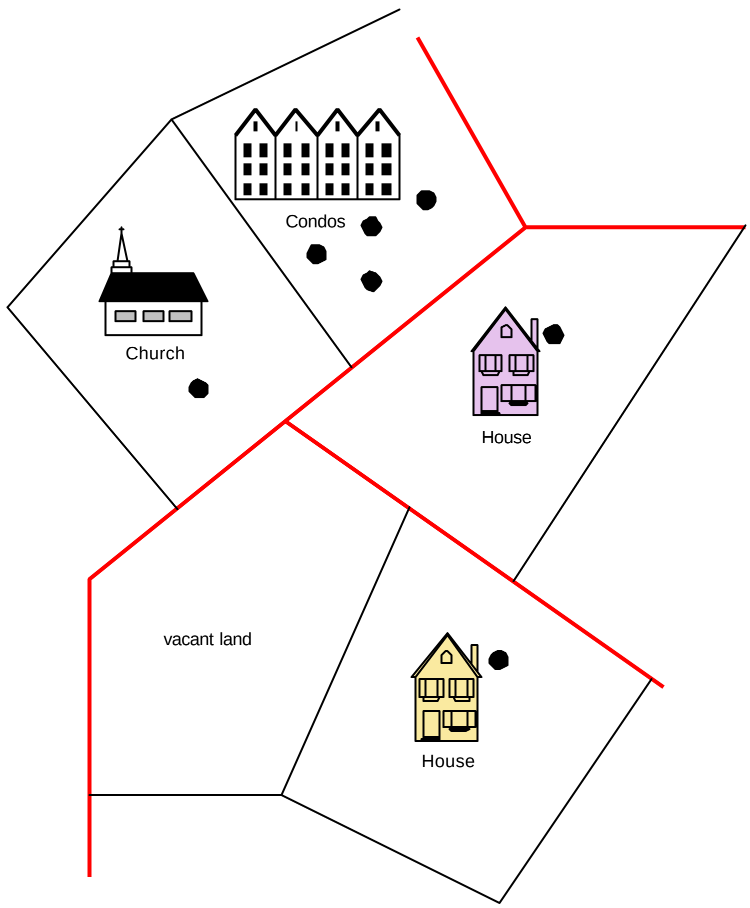


Figure 22 – Site Address Points

6.2 Regulated Uses and Restrictions

Regulated uses and restrictions are controls by a public body that limit the uses of land for the purposes of controlling development, maintaining property values, or implementing master plans or other plans. The most common form of regulated uses is zoning. Zoning is a government process that divides a jurisdiction into districts with specified limits and regulations on the nature, usage, and physical dimensions within the zones. (Black, 1991). Figure 23 is a photograph of a portion of a hand drawn zoning map, which is an example of a map of *Euclidean Zoning*. Some of the district designations on the map in Figure 23 are RD, IG, and BH. The information on the restrictions on the nature, usage, and physical dimensions, including setbacks and density for these districts is described in the Zoning Ordinance. In the diagram shown in Figure 23, the zoning district boundaries are contiguous with the parcel boundaries, but this may not always be the case.

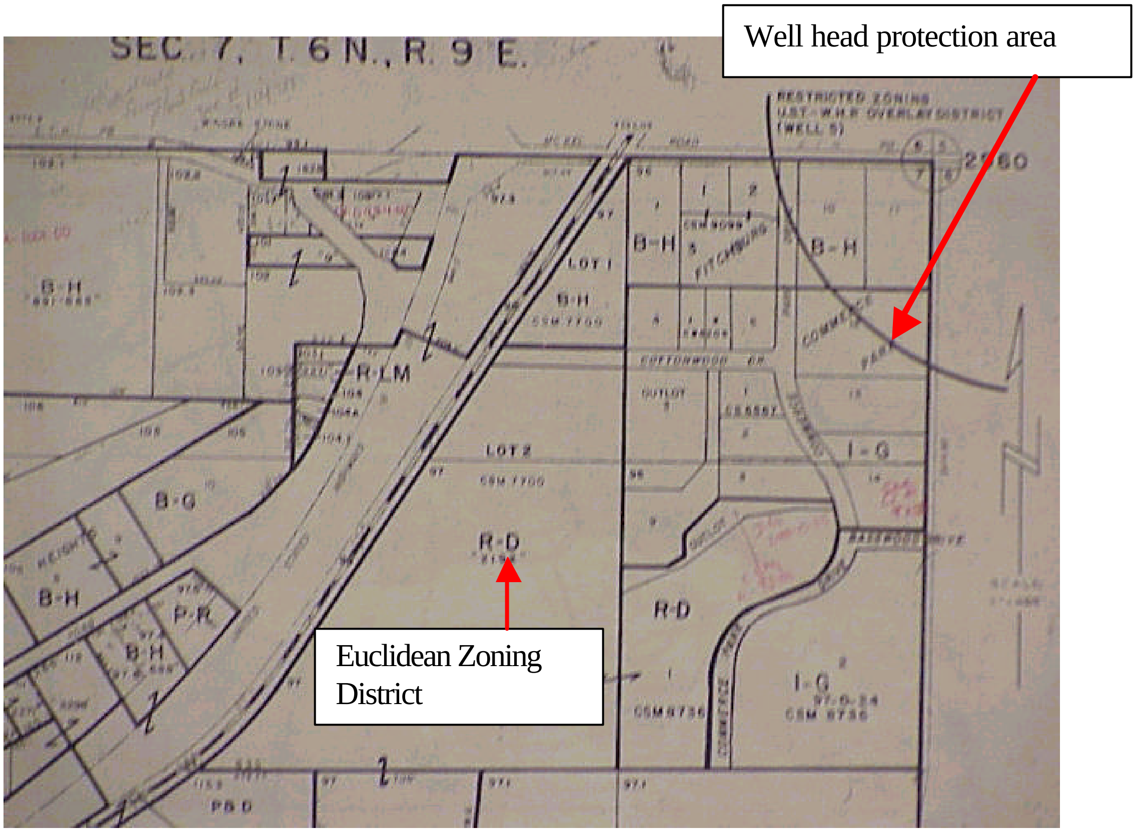


Figure 23 - Hand Drawn Zoning Map

Figure 23 also shows an overlapping district, a well head protection zone, that overlays the Euclidean Zoning. Towers and environmental restrictions may also create overlapping zoning regulations and hence overlapping zoning district polygons.

Figure 24 is an example of a Master Plan. This is anther tool that is commonly used for regulated use. In this case the Master Plan shows designated commercial and development areas. Like the map in Figure 23, the Master Planning zones are also contiguous with the parcel boundaries and in this case are built from the parcel boundaries.

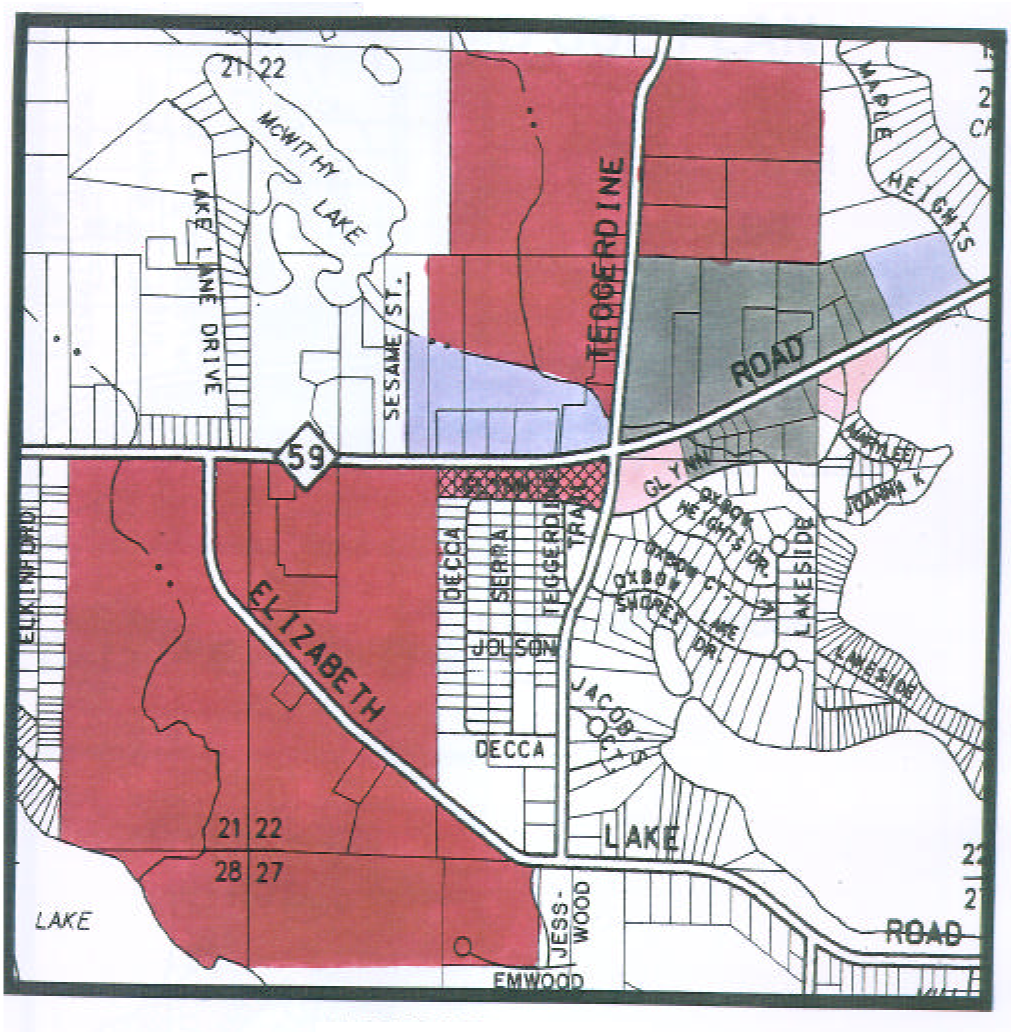


Figure 24 – Sample Master Plan

Another common type of restriction is a restrictive covenant. These are limitations in uses that are a part of the chain of title and run with the land.

6.3 Administrative Boundaries

Administrative boundaries are any division of land for managing or governing programs or agencies. The example in Figure 25 shows school district boundaries. These boundaries define what schools children attend and which school taxes are levied on the property tax roll. Notice that the school district boundaries do not follow the parcel boundaries. This is especially clear on the eastern side of the map where the school district boundary runs north of the right of way.

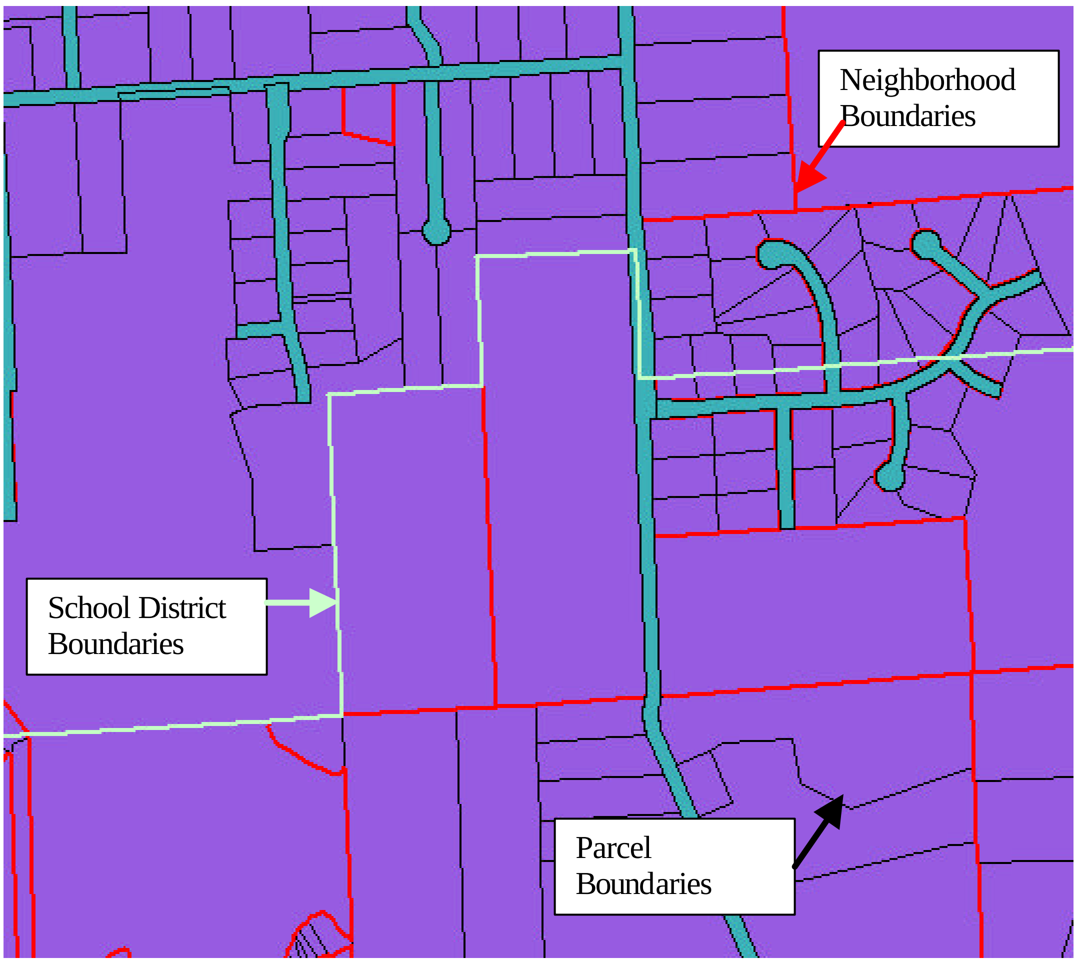


Figure 25 – Administrative Boundaries Derived from Parcel Boundaries

The other administrative boundaries shown in Figure 25 are neighborhoods. The neighborhoods generally parcel boundaries, although there are exceptions.

Counties, cities, villages, and towns or townships, and federal agency jurisdictions are other examples of administrative boundaries. These types of boundaries may benefit from parcel information as a reference or they may intend to follow parcel boundaries.

6.4 Features Classes

The feature classes described in this portion of the diagram are provided for informational purposes only. These features are not part of the ArcGIS Parcel Data Model, but they are closely related to it.

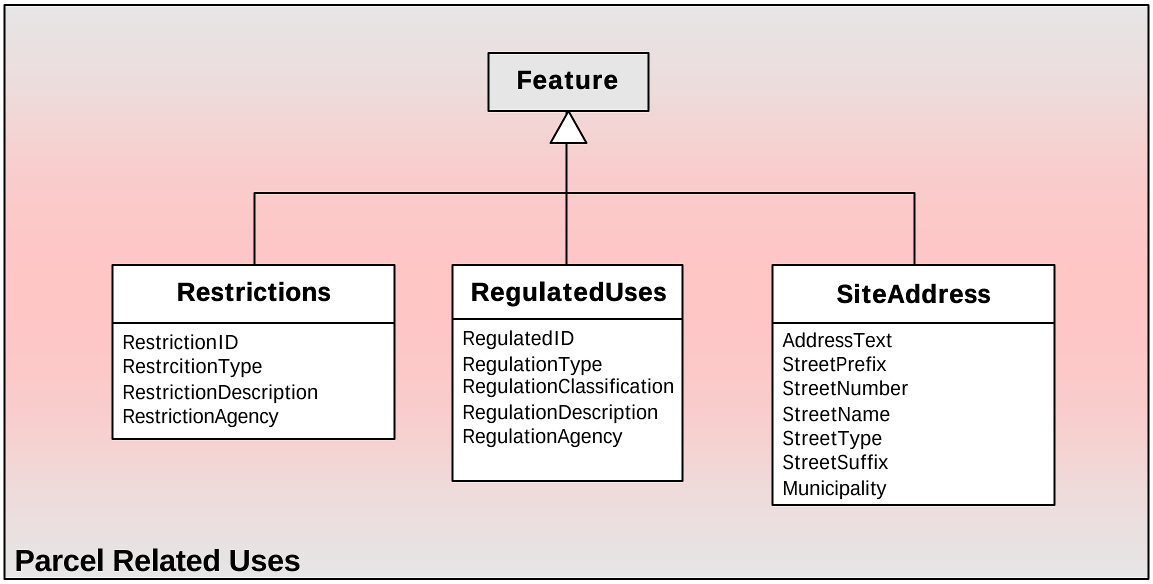


Figure 26 – Related Uses for Parcel Information

7. Corners and Boundaries

Corners and boundaries can be used to build parcel information. The corners are then ends of the boundaries and the boundaries are the lines connecting corners. In many jurisdictions the parcel maps begin with the definition of the corners and build up the parcel map through coordinate geometry or adjustments as described in Section 2 of this document.

The corners and boundaries features are based on the Federal geographic data Committee (FGDC) Cadastral Data Content Standard. The parcel is the heart of the FGDC Cadastral Data Content Standard. In this standard the parcel is defined by legal descriptions. Parcels are the spatial extent formed by record boundaries and corners, which are the end points of record boundaries. The attributes for corners and the record boundaries as described in the standard are information from public records. It is the information used to generate and label the parcel information.

7.1 Corners

Corners are parcel point features. As examples property corners form the exterior of parcels and public land survey corners are the exterior points of divisions of the Public Land Survey. Corners are usually monumented on the ground and are the physical manifestation of rights and interests in land. Landowners find their land on the ground by locating the corners.

Monuments can be made of a wide variety of materials and come in a wide variety of sizes. Many states have legislation that governs size and material for corner monuments of recorded surveys. A corner can have multiple monuments that are attempting to identify and locate the correct legal location of the corner on the ground. There is a significant body of evidence and professional procedure related to resolving multiple monuments through evidence evaluation.

The same construction methods used to determine parcel boundaries are used to establish coordinates on corners. These are cartographic construction, computations, and adjustments. The methods used to determine the coordinates are important because they help determine coordinate accuracy.

The ArcGIS Parcel Model accommodates multiple monuments for corners and multiple coordinates for corners and monuments. Knowing the relationship of corners to monuments and monuments to coordinates and knowing source and quality information of monuments and coordinates, is important to make informed decisions about which coordinate value for a parcel map.

The FGDC Cadastral Data Content Standard addresses this issue as well. The attributes for corners, monuments and coordinates are taken from the standard. The concept is to have GIS features that represent the physical realities of parcel corners and to capture sufficient information to support parcel mapping.

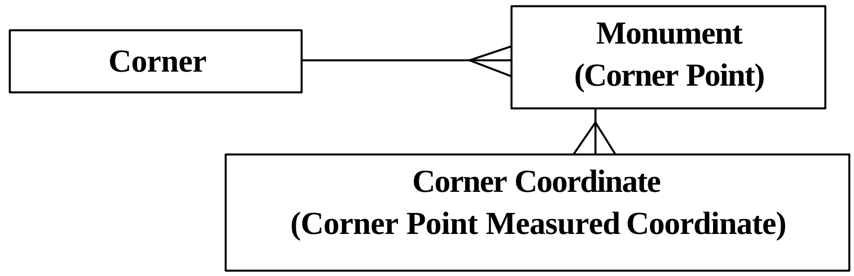


Figure 27 – Corners, Monuments and Coordinates

The symbols in Figure 27 are a shorthand that indicates a corner can have multiple monuments and a monument can have multiple coordinate values.

7.2 Boundaries

Boundaries are the exterior lines that form the parcel. In many jurisdictions coordinate geometry or least squares adjustments are used to compute the shape and extent of parcels. The information for the coordinate geometry and adjustments are usually extracted from information in the public records, such as recorded deeds or surveys. A jurisdiction can collect some or all of these attributes depending on the construction method and what information is available. Any of the attributes can be used for boundary annotation.

Ambulatory boundaries are boundaries that move. Rivers and other riparian features define the most common ambulatory boundaries. Natural features can be linked to boundaries to define an ambulatory boundary and are shown in the boundary feature.

7.3 Corner and Boundary Features

Figure 28 illustrates the corner and boundary features for ArcGIS Parcel Data Model. Corners are point features. Corners are marked by monuments, which are also point features, and in parcel mapping, monuments have coordinate values. Boundaries are linear features and are shown as a separate entity. Corners mark the ends of parcel boundaries.

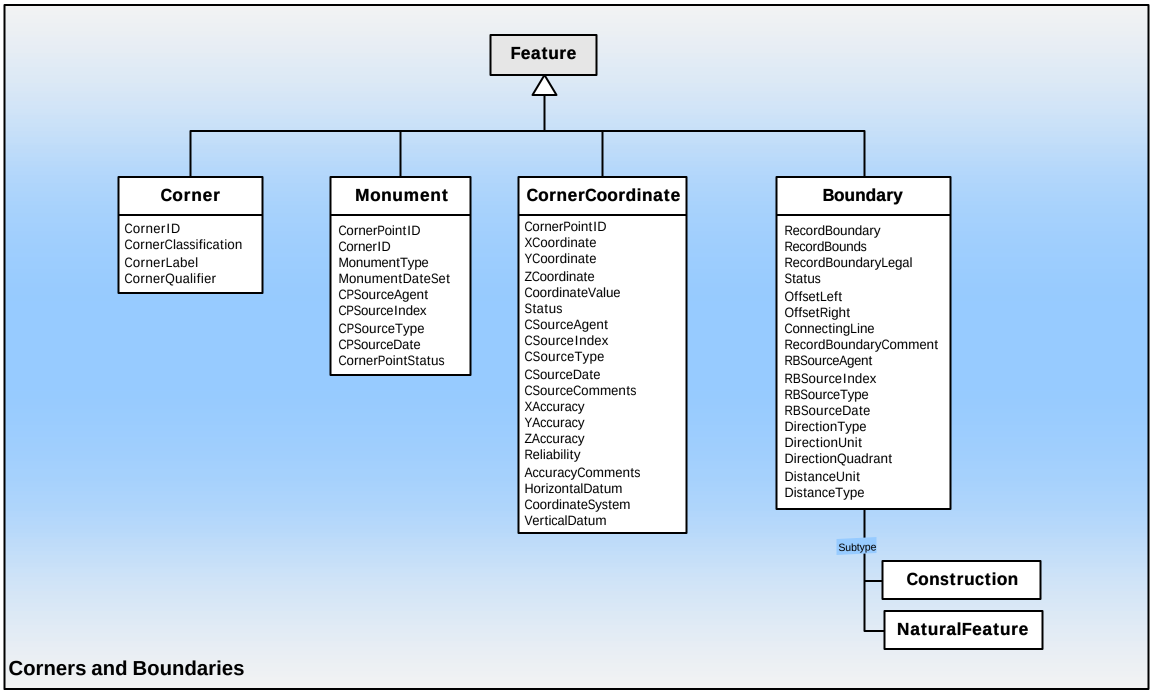


Figure 28 – Corner and Boundary Features

8. Geodatabase Overview for Parcel Users

This section defines the ArcGIS geodatabase elements that are used in the parcel data model. These concepts have been described more fully in *Modeling Our World* (Zieler, 1999) and are repeated here in terms of parcel information.

8.1 Objects

An *object* represents a real world object such as a tax bill or a property owner. An object is stored as a row in a relational database table.

Objects in the ArcGIS System do not have a geographic representation, such as a table of landowner names or a list of assessed parcel values. A table of tax bill address *objects* can be associated to a set of tax parcel *features* through a relationship class as shown in Figure 29.

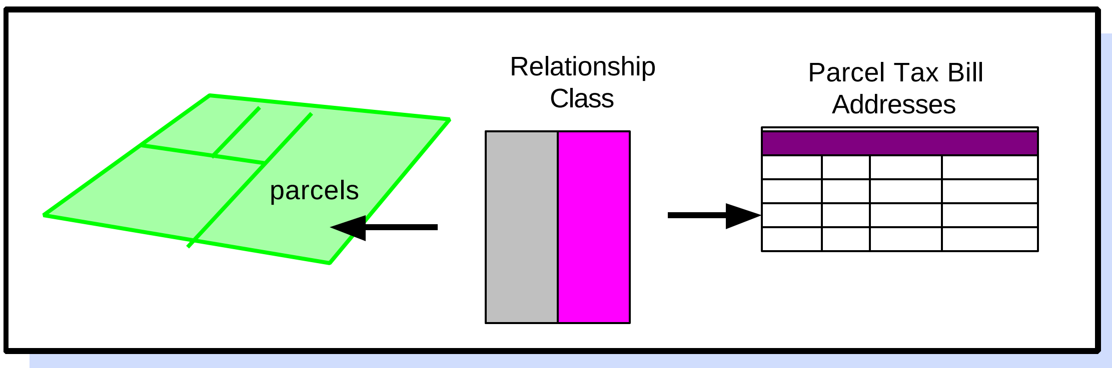


Figure 29 – Tax Bill Addresses and Parcel Features

8.2 Features

Features are geographic objects that have a spatial location defined. More specifically, a feature is just like an object but it also has a *geometry* or *shape* column in the relational database table for the object. Through inheritance a feature has all of the methods of the Object class, but it also has more methods. One way to think of this is that a feature is a special kind of object with additional capabilities.

For example, Tax Parcels and Owner Parcels are polygon feature classes in the Parcel Model. Each type of parcel has different attributes and topological rules, creating the need for two separate feature classes. Remember that a feature class is just another table in the database, so just like any other database; if we want to have different fields for Tax Parcels and Owner Parcels then we need different tables. In the geodatabase these columns are referred to as attributes or properties.

In addition to needing different classes when features have different attributes, a feature class is constrained to be a collection of features with the same type of geometry: point, line, or polygon. Each type of geometry requires a separate feature class.

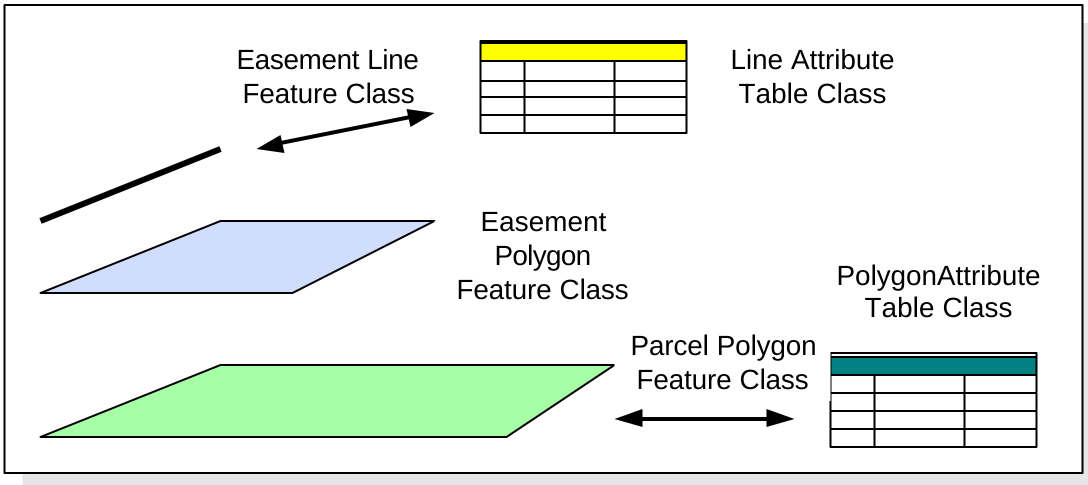


Figure 30 – Line – Polygon and table Feature Classes

Simple feature classes contain points, lines, polygons, or annotation without any topological rules between them. The geodatabase also has the concept of more sophisticated feature classes, such as network features and topological features. Network Features inherit from the *NetworkFeature* class and each feature class participates in a geometric network. As an example, if water valves and mains are in the same geometric network, if we move the valve the pipes will stretch, keeping their physical connection to the valves.

In the parcel world *Topological* features are of more interest because they describe the relationships between and within polygon feature classes. Special topological features are under development for the ArcGIS 8.2 release. Right now you can use the simple polygon feature classes to build a database that will be ready for these enhancements. As much as possible the ArcGIS Parcel Data Model represents a practical way to build your parcel management polygons today in a way that will easily transition to future ArcGIS releases.

8.3 Feature Datasets

A feature dataset is simply a collection of feature classes that share a common *spatial reference*. A spatial reference is part of the definition of the geometry field in the database. As an example, a set of parcels stored in NAD27, UTM Zone 5 could not be in the same feature dataset as Public Land Survey System features stored in geographic Latitude/Longitude coordinates. Topological feature classes are bound within a topology graph that manages the feature classes in an integrated topological unit. You may choose to organize feature classes in multiple feature datasets, but related topological feature classes must be contained within the same feature dataset so that topological relationships are not broken due to minor differences in mathematical calculations between geometries in different spatial references.

8.4 Topological Features in the ArcGIS Parcel Model

Some agencies may have many feature classes in their parcel feature datasets and other will have fewer feature classes. One of the important aspects of the Parcel Data Model is a better understanding of the design trade-offs involved in topological relationships and some guidelines for your own project.

8.5 Relationships

Three types of relationships can exist between objects or features: spatial, explicit and topological.

Spatial relationships are merely the spatial coincidence of features. For example, rather than storing which Tax District that a parcel is located in as an attribute of the parcel, a spatial operator like “is inside of” can be used to determine which tax district the parcel falls within. These are capabilities inherent in a GIS system that simplifies the process of data maintenance and analysis over a basic relational database system. Sometimes, however, you will need to maintain more specific information about related objects and features.

Explicit relationships are created between objects as a relationship class. One object serves as the origin class and the other object is referred to as the destination class. These are similar to the primary and foreign key relationships in relational databases; the geodatabase has its own infrastructure for managing these relationships in a versioned database environment. ArcInfo also provides the ability for objects to *message* each other as part of the relationship definition. This provides programmers the ability to build sophisticated behavior into objects. In this explanation we have used the word *object*, but since *features* are a special kinds of *objects*, explicit relationships apply to any and all kinds of features in the ArcGIS system.

As an example, we might want to send a message to TaxBillAddress objects when a related TaxParcel is made historical. Based on rules built into the TaxBillAddress object, the related addresses could decide whether to update their own status to historical or to sever the relationship to the single historical parcel if other TaxParcels are still using this address. The key point is that the behavior is programmed into the TaxParcel and TaxBillAddress objects, not into a specific application or tool that is separate from the objects.

In this way, ArcInfo manages both the attributes and behavior of objects, and programmers work in an object-component environment that is abstracted from the underlying physical database model and augmented by a programming framework of many interfaces and methods. The geodatabase provides the object-relational mapping and manages the integrity of the data in the underlying database. Explicit relationships are one way to trigger behavior in the system but you should be careful to select the smallest set of relationships possible and understand how relationships impact system behavior. More information on this topic can be found in *Building a Geodatabase* in your ArcInfo documentation set.

Examples of topological relationships are geometric networks and planar topologies. As mentioned previously, geometric networks result in system behavior that ensures the connectivity of a network data model. Planar topologies ensure that rules within and between feature classes in a feature dataset are enforced through topological graphs. One example of this is that ownership polygons are not allowed to overlap each other.

References

Black, Henry Campbell, Blacks Law Dictionary, 1991, sixth edition, West Publishing, St Paul, Minnesota, 1132 pages.

Brown, et al, (1995), Brown's Boundary Control and Legal Principles, fourth edition, John Wiley and Sons, New York, New York, 410 pages.

Brown, Curtis, (1969), Boundary Control and Legal Principles, second edition, John Wiley and Sons, New York, New York, 371 pages.

Federal Geographic Data Committee, 1999, Cadastral Data Content Standard for the National Spatial Data Infrastructure, Version 1.1, Subcommittee on Cadastral Data, Reston, Virginia.

Moyer, D. David, and Fisher, Kenneth Paul, 1973, Land Parcel Identifiers for Information Systems, American Bar Foundation, Chicago Illinois.

Wattles, G.H., 1979, Writing Legal Descriptions, Gurdon H Wattles Publications, P.O. Box 5702, Orange, CA 92667.

Zeiler, Michael, (1999), Modeling our World, ESRI Press, Redlands California, 199 pages.